Designing Interactive Toys for Elephants

Conference or Workshop Item

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Abstract
This research is investigating the potential for designing digital toys and games as playful cognitive enrichment activities for captive elephants. The new field of Animal Computer Interaction is exploring a range of approaches to the problem of designing user-centred systems for animals and this investigation into devices for elephants aims to directly contribute towards a methodological approach for designing smart and playful enrichment for all species.

Author Keywords
Animal Computer Interaction; toy design; game design; elephant; environmental enrichment; participatory design; play

ACM Classification Keywords
H.5.2. User interfaces.

Introduction
Humans currently maintain animals in captivity in a variety of contexts. None of these animals are independent any more, which means that the responsibility for their welfare falls to the humans who keep them.

The contemporary point of view is that the same conditions of welfare apply to all members of a species,

Play in Animals

What: Play in animals is easy to recognise, but challenging to define because is it such a fluid and transient behaviour with no immediately obvious cause (Bekoff and Byers, 1998; Sendova-Franks and Scott, 2012).

Why: Current research favours the idea that play prepares animals for their future lives by refining the control that the prefrontal cortex has over other parts of the brain, allowing the animal to become more adaptable (Pellis et al 2014).

Who: People used to believe that only humans, primates and dogs were capable of play, but research has shown that many mammals, some reptiles and some fish also exhibit this kind of behaviour (Burghardt, 2005).

Types: There are three recognised types of play behaviour in non-human animals - social play, locomotor play and object play (Burghardt in Bekoff and Byers, 1998).

whether domesticated (pets, stray, farmed, laboratory) or wild (in zoos, sanctuaries and labs or living freely as part of the natural world). However, the case of elephants is emblematic of how these captive animals may face a number of welfare challenges [4], including lack of exercise and stimulation, due to space restrictions, limited numbers of conspecifics and the ready availability of food. In general, they are not required to use their brains to full capacity, which can lead to a range of psychological and physiological problems, such as boredom and associated stress.

Young [2] explains that the provision of environmental enrichment improves animal welfare in two ways - it empowers an animal by allowing it to express control over its environment and it reduces the animal's level of fear by giving it appropriate stimulation. These factors help to maintain the animal in good physical and psychological health. Similarly, delivering enrichment to a species has potential for empowering the care-giver, by providing opportunities to investigate, design and evaluate the interventions.

This research in the area of Animal Computer Interaction [1] is exploring the potential for using technology to support the delivery of novel environmental enrichment experiences for captive elephants. The focus of the interventions is to stimulate playful behavior, because there is consensus that this decreases stress levels and is good for welfare [3].

Technology Mediated Play

We humans have come to rely on technology to provide us with much of our modern stimulation. Living in urban environments with limited freedom and space, but arguably with more recreational time than our ancestors, we have adapted to use digital forms of entertainment in addition to our traditional cultural forms of storytelling, sports, music, dance, art and playing games.

Recent developments have seen the gap between toys and games grow smaller, with a new trend emerging towards "enhanced" toys, meaning that they include embedded technology that links them to a computer application and potentially a network. Some of these toys inhibit free play because their integration with a formal system imposes a game-like structure on the player. Computer games, meanwhile, are becoming less dependent on traditional screens and peripherals as novel interfaces enable different kinds of interactivity in different locations.

While it may be difficult to predict how an animal will behave if given an opportunity to interact with a playful device that has a set of rules (logic) underpinning its functionality, the 'fusion' between toy and game modalities might make this type of playful stimulation more accessible to non-human animals by promoting less abstract, yet structured forms of engagement. In this respect, current trends present new opportunities.

Indeed, there has already been some research into ways of utilizing technology to create new enrichment experiences for captive animals [4], including concepts that have focused on playful technology [5] [6], but the field is still emerging with the potential for further insights to be drawn.

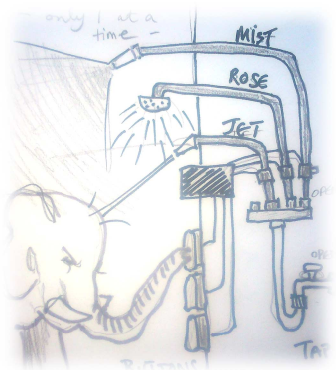

Figure 1: Example concept sketch for interactive shower

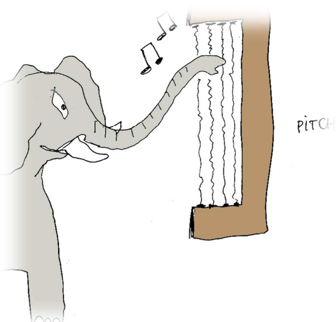

Figure 2: Example concept sketch for acoustic toy

Enrichment for Elephants
Elephants are known to be playful, and demonstrate locomotor, object and social play all their lives [9]. In addition, because the lifestyle enjoyed by wild elephants is very different from the experience of captive animals, zookeepers are always looking for new ways to enrich their elephants' enclosures.

Elephants pose an interesting challenge from the perspective of interaction design, because they perceive and interact with the world very differently from humans. Additionally, their physical characteristics, such as size and weight, impose extreme constraints on the design process. All species of elephant seem to use the same modalities for communicating with each other and interacting with the world, and these are the key practical aspects of elephant behaviour that designers need to understand in order to develop an interactive toy that an elephant is able to use. What would an elephant find engaging as well as possible to engage with? Schell states: "The most important skill for a game designer is listening (to the players)." [10] How is it possible to listen to an elephant, given the challenges that inter-species communication barriers pose for designers?

To address these challenges we have taken a multi-pronged approach. Firstly, we wanted to understand what might be feasible for an elephant with regard to using controls and receiving feedback from a device. To this end, we have conducted an extensive literature review about their natural behavior and interaction with the world, for example in terms of lifestyle, communication (preferred modes of interaction) and dexterity (physical abilities). Secondly, we undertook an ethnographic study in order to appreciate the specific environments and contexts in which different captive elephants find themselves, for example in terms of habitat, daily habits or social interactions.. Thirdly, we wanted to involve the elephants themselves in the design process to gather their responses thus enabling the elephants to influence the design process. To this effect, we prototyped some of our design concepts and tested them with the elephants.

Toy Design Characteristics

There are two distinct strands to this work – the design of the toy itself and the design of the interface. The two aspects are deeply integrated, as the interface serves as a metaphor for the underlying system architecture and the feedback from the system is inherent in the playability of the toy. Our findings so far indicate that both the elephants' biological characteristics and their contextual circumstances play an important role in the design development.

Biology
In our literature search we found that elephants have highly sophisticated hearing but that their vision is not so developed [11]. Additionally, their trunks are very sensitive and dexterous, and they often investigate crevices and other small spaces with their trunk tips, to explore the environment as well as forage. This suggests that modalities for interfacing with a toy/game should focus on tactile and acoustic properties, rather than relying on a visual display. In practice, our observations of elephants interacting with prototypes indicate that they might understand a tangible, physical interaction with a system.

Figure 3: Valli listens to didgeridoo

Figure 4: Reaching for pipe buttons through the wall

Figure 5: Valli activates the water supply

Context

During our ethnographic work, it soon became clear that captive elephants in the UK are not a homogenous group. Quite apart from being different species (African and Asian), they all find themselves in unique situations. Some have NC (no contact) with their human keepers; some have PC (protected contact, where the keeper is always on the other side of a barrier) while there are yet others who have FC (full contact). The majority are housed with at least one other elephant, although there are exceptions. Many animals are kept with conspecifics who are not their immediate family and very few have the experience of being part of a herd. Even when elephants are housed in similar conditions, their behaviours, interests and attitudes vary, as evidenced by the different ways in which they play.

Our toy designs need to account for these individual differences, as they will influence the way in which different elephants may be able and willing to engage. For example, a matriarch will dominate activities within a group, therefore care has to be taken to ensure that everyone in the vicinity is being enriched. This background research, combined with discussions with animal welfare experts and elephant keepers, has enabled us to develop a number of design concepts (See Figures 1 and 2 for examples).

Since environmental enrichment aims to encourage species-appropriate behaviours across a range of categories, the interactive toys should aim to give the captive elephant an experience that shares some features of an experience enjoyed by a wild elephant, or which encourages the elephant to practice some of the skills that a wild elephant would naturally deploy.

Zoos and wildlife parks currently offer their elephants a range of enrichment, therefore the focus of the toy design is on gaps in provision, with the goal of using technology to offer something new.

Currently, we are offering one of our play-testers (Valli at Skanda Vale Ashram) a range of prototypes, allowing her to make choices and monitoring her responses. Below we describe three examples and related findings.

Prototyping and Evaluation

Each intervention has clear goals, relating to its potential for playful enrichment, its game design characteristics, its usability for an elephant and the technical challenges involved. Each intervention was discussed and planned with Valli's caretakers.

Participatory Design1: Low Frequency Audio

- **Playful Enrichment Goal** [Sensory - acoustic]: See if Valli shows interest in low frequency sounds and establish that such noises will not upset her.
- **Game Design Goal**: Determine if hearing low frequency sounds could be a motivating experience.
- **Usability Goal**: Find out if audio could be used as a feedback device.
- **Technical Goal**: Test speakers for low frequency sound production.

This was designed to test potential output modalities prior to developing an interactive acoustic toy using low frequency audio as a feedback mechanism. Audio in the range 60-70Hz seemed to generate the most interest and none of the sounds upset Valli, according to keepers' observations and interpretations of her stance. (See Figure 3)

Participatory Design 2: Audio Pipe Button

- **Playful Enrichment Goal** [Physical - trunk-tip exercise; Cognitive – exploration and comprehension; Sensory – tactile and acoustic]: Devise a simple on/off button that Valli can activate and which can be repurposed for different situations.
- **Game Design Goal**: See if Valli enjoys using buttons to activate sounds.
- **Usability Goal**: Identify location and position of buttons; modify size to suit trunk tip.
- **Technical Goal**: Calibrate capacitance sensors to vary pitch as trunk moves down pipe; produce robust, homemade sensors that control an audio signal.

This also tested whether Valli would investigate buttons placed behind barriers, essential for safety and to avoid the prototypes being destroyed. The sensors were placed at the end of a length of drainpipe, reasoning that Valli would be motivated to feel inside with her trunk out of curiosity.

Capacitance sensing relies on proximity of the human or animal to the sensor, with no contact required. The advantage is that a trunk tip in the vicinity will activate it and therefore no special movements need to be made. The disadvantage is that the sensor provides no feedback to show it has been activated, unlike a toggle switch, for example, which changes position. Feedback can however be generated by the system that is being controlled, and in this case we used a small piezo buzzer. This had the additional advantage of being non-visual feedback, which suited the location of the buttons, on the other side of a wall and accessed via a browsing hole. (See Figure 4)

Valli had no difficulty locating and activating this prototype, evidenced by videos documenting her investigations.

Participatory Design 3: Water Valve Control

- **Playful Enrichment Goal** [Physical - trunk-tip exercise; Cognitive – exploration and understanding; Sensory – tactile]: Allow Valli to activate the water supply using a simple button.
- **Game Design Goal**: Find out if activating the shower is motivating; if Valli touches button out of curiosity and if she repeats voluntarily.
- **Usability Goal**: Can she reach and press the button? Is it clear what the button is doing?
- **Technical Goal**: Devise a system to control water supply so that can be activated by an elephant – solenoid water valve with plastic push-to-make button input on Arduino via relay switch.

A shallow bucket button was first mounted on the ceiling just outside Valli's enclosure, so she could just reach it with her trunk. The hose was directed onto the rubber mat in this zone, which is where she usually has a wash (See Figure 5). It took the keepers longer to encourage Valli to press this button, compared with the pipe buttons installed through the browsing hole.

When she activated the system, there was a short delay before water came out, because it had to travel from the valve to the end of the hosepipe. When the water sprayed the mat, Valli moved back sharply. As soon as she was left alone with the device, she lost no time in pulling down the hosepipe and destroying it, which we took to be a likely indication of her opinion.

Future Plans

The work is on-going, with plans to offer Valli a variety of different enrichment devices over the forthcoming months. We hope that the provision of simple controls will enable Valli to realize that an interface can enable her to create changes in her environment, which in turn will lead her to explore the potential of more interactive toys. e will also explore the possibility of integrating data-logging in our prototypes and enabling adaptive system development. For example, instead of second-guessing what feedback Valli prefers, we could offer a range of choices, record her interaction with the system and dynamically adjust it, based on her input, in order to refine the options.

It is anticipated that the outcomes will be of interest to the game design community, to the wider HCI community and potentially to researchers in the field of animal behaviour. Designing for different modalities contributes directly towards a diversity agenda, while finding out more about what drives play behaviour and how to design a system with which different species can interact could have positive impacts on animal welfare and potentially contribute towards stress management in captive populations.

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